

E 1.28: SOLAR/1017-79/02



Alpha 1215966

SCLAR/1017-79/02

# Monthly Performance Report

FACILITIES DEVELOPMENT

FEBRUARY 1979



## U.S. Department of Energy

National Solar Heating and  
Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT  
FACILITIES DEVELOPMENT GAS COMPANY  
FEBRUARY 1979

I. SYSTEM DESCRIPTION

The Facilities Development Gas Company site is a three-story, multifamily condominium consisting of 31 units in San Diego, California. Solar energy is used for preheating domestic hot water (DHW) for the complex. The solar energy system has an array of flat-plate collectors with a gross area of 520 square feet. The array faces south at an angle of 42 degrees to the horizontal. Potable water is the transfer medium that delivers solar energy from the collector array to storage. Solar energy is stored underground in an insulated 1000-gallon glass-lined tank. Preheated water from the storage tank is supplied, on demand, to 31 conventional 52-gallon DHW tanks. When solar energy is insufficient to satisfy the hot water load, two electrical heating elements, energized separately within the individual DHW tanks, provide auxiliary energy for water heating. The system, shown schematically in Figure 1, has two modes of solar operation.

Mode 1 - Collector-to-Storage: This mode activates when the water temperature in the collectors is 9°F higher than the temperature of the storage tank. Water is pumped through the collectors and circulates back to storage until the temperature difference is 3°F or less.

Mode 2 - Storage-to-DHW Tank: This mode activates when there is a demand for hot water replenishment by the individual DHW tank. Water from storage circulates by thermosiphoning action through a supply service loop to the individual DHW tanks and returns through a service line to storage. The water in each DHW tank is maintained at an average temperature which is thermostatically controlled. When required, additional energy is supplied by an electrical auxiliary element.

II. PERFORMANCE EVALUATION

INTRODUCTION

The site was occupied in February and the solar energy system operated continuously during the month. Solar energy satisfied 21 percent of the DHW requirements. The solar energy system provided electrical energy savings of 8.9 million Btu.

WEATHER CONDITIONS

During the month, total incident solar energy on the collector array was 25.0 million Btu for a daily average of 1719 Btu per square foot. This was below the estimated average daily solar radiation for this geographical area

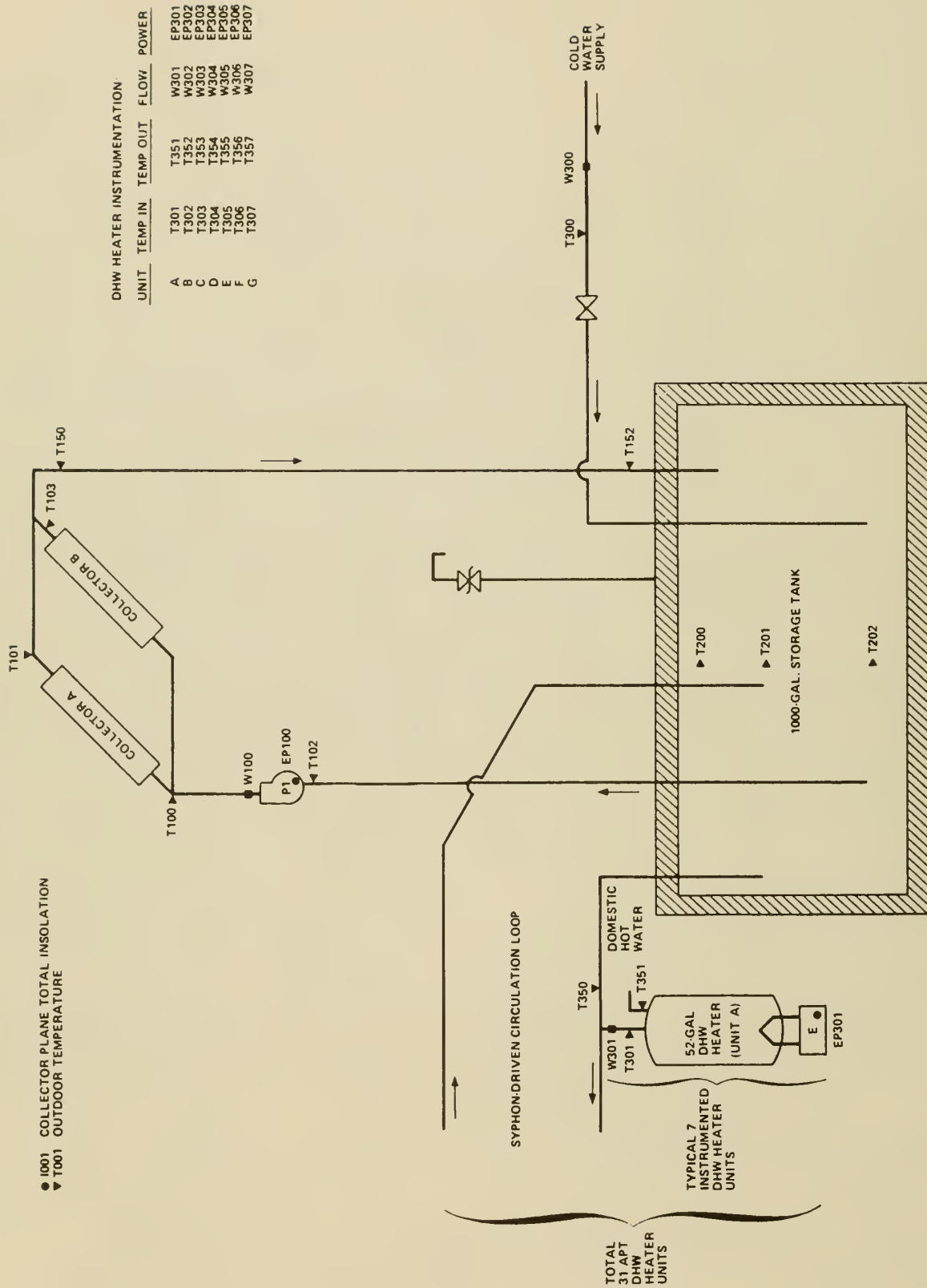


Figure 1. FACILITIES DEVELOPMENT SOLAR ENERGY SYSTEM SCHEMATIC



during February of 1757 Btu per square foot for a south-facing plane with a tilt of 42 degrees to the horizontal. The average ambient temperature during February was 53°F as compared with the long-term average for February of 57°F. The number of heating degree-days for the month (based on a 65°F reference) was 326, as compared with the long-term average of 237.

## THERMAL PERFORMANCE

System - During February the solar energy system performed approximately the same as expected. The expected performance was determined from a modified f-chart analysis using measured weather and subsystem loads as inputs. Solar energy collected was 11.2 million Btu versus an estimated 11.4 million Btu. Solar energy used by the system was estimated by assuming that all energy collected would be applied to the load. Actual solar energy used was 9.2 million Btu. System total solar fraction was 21 percent versus an estimated 26 percent.

Collector - The total incident solar radiation on the collector array for the month of February was 25.0 million Btu. During the period the collector loop was operating, the total insolation amounted to 22.8 million Btu. The total collected solar energy for the month of February was 11.2 million Btu, resulting in a collector array efficiency of 45 percent, based on total incident insolation. Solar energy delivered from the collector array to storage was 9.8 million Btu. Energy loss during transfer from the collector array to storage was 1.4 million Btu. This loss represented 12 percent of the energy collected. Operating energy required by the collector loop was 0.23 million Btu.

Storage - Solar energy delivered to storage was 9.8 million Btu. There were 9.2 million Btu delivered from storage to the DHW subsystem. Energy loss from storage was 0.78 million Btu. This loss represented 8 percent of the energy delivered to storage. The storage efficiency was 92 percent: This is calculated as the ratio of the sum of the energy removed from storage and the change in stored energy, to the energy delivered to storage. The average storage temperature for the month was 95°F.

DHW Load - The DHW subsystem consumed 9.2 million Btu of solar energy and 35.4 million Btu of auxiliary electrical energy. The solar fraction of the hot water load was 21 percent. The hot water load was not determined. The DHW subsystem resulted in an electrical energy savings of 9.2 million Btu. A daily average of 934 gallons of DHW was consumed.

## OBSERVATIONS

The collected solar energy, the collector loop operating energy, energy delivered to storage, solar energy used, and hot water consumed, were derived from overall solar energy system parameters. The auxiliary electrical energy used (representing the entire building) was extrapolated from the averages of seven instrumented apartment units.

The hot water load and the average value of the hot water temperature supplied to the building has not been determined because of inadequate instrumentation.

#### ENERGY SAVINGS

The solar energy system provided a total electrical energy savings of 8.9 million Btu.

#### III. ACTION STATUS

No action is required at this time.

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT SITE SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: FEBRUARY, 1979

SD-AP/1017-79/02

### SITE/SYSTEM DESCRIPTION:

THE FACILITIES DEVELOPMENT SOLAR SYSTEM PROVIDES SERVICE HOT WATER TO 31 UNITS OF A CONDOMINIUM. ALL UNITS HAVE 52 GALLON ELECTRIC WATER HEATERS. SEVEN OF THESE ARE INSTUMENTED. THE ARRAY OF FLAT-PLATE COLLECTORS PROVIDES 820 SQUARE FEET OF GROSS AREA. STORAGE IS PROVIDED BY A SINGLE 1000 GALLON GLASS LINED TANK, INSULATED AND BURIED.

### GENERAL SITE DATA:

INCIDENTAL SOLAR ENERGY  
26.403 GIGA JOULES  
546337 KJ/SQ.M.  
11.770 GIGA JOULES  
243639 KJ/SQ.M.  
12 DEGREES C  
N.A. DEGREES C  
0.37  
0.238 GIGA JOULES  
0.238 GIGA JOULES  
49.350 GIGA JOULES

### COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE  
AVERAGE BUILDING TEMPERATURE  
GROSS SOLAR CONVERSION EFFICIENCY  
GROSS OPERATING ENERGY  
TOTAL SYSTEM OPERATING ENERGY  
TOTAL ENERGY CONSUMED

### SUBSYSTEM SUMMARY:

LOAD  
SOLAR FRACTION  
SOLAR ENERGY USED  
OPERATING ENERGY  
AUX. THERMAL ENRG  
AUX. ELECTRIC FUEL  
AUX. FOSSIL FUEL  
ELECTRICAL SAVINGS  
FOSSIL SAVINGS

HOT WATER  
N.A.  
N.A.  
9.667  
N.A.  
37.343  
37.343  
N.A.  
9.667  
N.A.

HEATING  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.

COOLING  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.  
N.A.

SYSTEM TOTAL  
N.A. GIGA JOULES  
N.A. PERCENT  
0.567 GIGA JOULES  
0.238 GIGA JOULES  
37.343 GIGA JOULES  
37.343 GIGA JOULES  
N.A. GIGA JOULES  
9.426 GIGA JOULES  
N.A. GIGA JOULES

### SYSTEM PERFORMANCE FACTOR:

\*

\* DENOTES UNAVAILABLE DATA

N DENOTES NO DATA

N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT  
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,  
SD-AP/0004-79/18

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT SITE SUMMARY

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: FEBRUARY, 1979

SOLAR/1017-79/02

### SITE/SYSTEM DESCRIPTION:

THE FACILITIES DEVELOPMENT SOLAR SYSTEM PROVIDES SERVICE HOT WATER TO 31 UNITS OF A CONDOMINIUM. ALL UNITS HAVE 52 GALLON ELECTRIC WATER HEATERS. SEVEN OF THESE ARE INSTRUMENTED. THE ARRAY OF FLAT-PLATE COLLECTORS PROVIDES 220 SQUARE FEET OF GROSS AREA. STORAGE IS PROVIDED BY A SINGLE 1000 GALLON GLASS LINED TANK, INSULATED AND BUPIED.

### GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	25.026	MILLION BTU
COLLECTED SOLAR ENERGY	48123	BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	11.156	MILLION BTU
AVERAGE BUILDING TEMPERATURE	21455	BTU/SQ.FT.
EXCESS SOLAR CONVERSION EFFICIENCY	53	DEGREES F
EXCESS OPERATING ENERGY	N.A.	DEGREES F
TOTAL SYSTEM OPERATING ENERGY	0.37	MILLION BTU
TOTAL ENERGY CONSUMED	0.225	MILLION BTU
	0.225	MILLION BTU
	46.777	MILLION BTU

### SUBSYSTEM SUMMARY:

LOAD	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
SOLAR FRACTION	N.A.	N.A.	N.A.	N.A.
SOLAR ENERGY USED	N.A.	N.A.	N.A.	N.A.
OPERATING ENERGY	9.163	N.A.	N.A.	9.163
AUX. THERMAL ENERGY	N.A.	N.A.	N.A.	0.225
AUX. ELECTRIC FUEL	35.396	N.A.	N.A.	35.396
AUX. FOSSIL FUEL	35.396	N.A.	N.A.	35.396
ELECTRICAL SAVINGS	N.A.	N.A.	N.A.	N.A.
FOSSIL SAVINGS	9.163	N.A.	N.A.	8.935
	N.A.	N.A.	N.A.	N.A.

### SYSTEM PERFORMANCE FACTOR:

\*

\* DENOTES UNAVAILABLE DATA  
\* DENOTES NULL DATA  
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT  
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,  
SOLAP/0004-78/18



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SOLAR/1017-79/02

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: FEBRUARY, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.752	51	0.163	NOT APPLICABLE	0.008	NOT APPLICABLE	0.217
2	0.718	49	0.193		0.006		0.268
3	0.770	51	0.232		0.005		0.384
4	1.108	49	0.251		0.009		0.226
5	1.049	50	0.267		0.009		0.253
6	1.033	51	0.349		0.009		0.338
7	0.953	53	0.362		0.008		0.379
8	0.874	53	0.408		0.007		0.466
9	0.823	54	0.275		0.007		0.290
10	1.058	52	0.394		0.008		0.372
11	1.047	54	0.444		0.008		0.424
12	1.084	54	0.345		0.008		0.318
13	1.106	55	0.340		0.008		0.308
14	0.944	56	0.446		0.008		0.477
15	0.946	51	0.330		0.008		0.358
16	0.924	55	0.397		0.008		0.430
17	1.105	53	0.428		0.009		0.388
18	0.938	54	*		0.008		*
19	0.559	55	0.300		0.007		0.453
20	0.551	55	0.236		0.008		0.421
21	0.778	57	0.286		0.008		0.368
22	0.879	56	0.404		0.008		0.449
23	0.906	55	0.291		0.008		0.321
24	0.552	54	0.285		0.005		0.315
25	1.125	55	0.345		0.010		0.307
26	0.458	55	0.284		0.007		0.520
27	1.101	54	0.391		0.010		0.353
28	1.085	54	0.370		0.010		0.349
SJM	25.225	-	9.163	N.A.	0.225	N.A.	-
AVG	0.894	53	0.327	N.A.	0.008	N.A.	0.355
NBS TO	0001	1113	-	-	0102	-	1111

\* DENOTES UNAVAILABLE DATA.

2 DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT COLLECTOR ARRAY PERFORMANCE

SITE: FACILITIES DEVELOPMENT GAS COMPANY SC-AR/1017-79/02  
REPORT PERIOD: FEBRUARY, 1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.752	0.696	0.361	57	0.480
2	0.718	0.643	0.325	56	0.452
3	0.339	0.220	0.120	57	0.354
4	1.108	1.031	0.467	59	0.421
5	1.049	0.955	0.423	61	0.403
6	1.033	0.964	0.421	61	0.407
7	0.953	0.878	0.408	62	0.428
8	0.874	0.792	0.388	57	0.444
9	0.923	0.866	0.446	59	0.484
10	1.058	0.920	0.432	62	0.408
11	1.047	0.954	0.492	64	0.470
12	1.084	1.018	0.476	65	0.439
13	1.106	1.007	0.491	67	0.435
14	0.944	0.830	0.428	60	0.444
15	0.946	0.865	0.420	59	0.449
16	0.924	0.855	0.415	61	0.450
17	1.105	1.028	0.497	61	0.482
18	0.938	0.864	0.452	62	0.474
19	0.659	0.564	0.312	61	0.437
20	0.561	0.499	0.245	61	0.454
21	0.778	0.697	0.353	59	0.483
22	0.899	0.855	0.434	59	0.483
23	0.906	0.827	0.406	60	0.407
24	0.552	0.439	0.225	62	0.453
25	1.125	1.074	0.510	65	0.435
26	0.458	0.383	0.190	60	0.479
27	1.101	1.055	0.527	62	0.455
28	1.085	1.035	0.494	63	0.455
SUM	25.026	22.834	11.156	-	-
AVG	0.894	0.816	0.398	61	0.446
NRSD	0001	-	0100	-	N100

\* DENOTES UNAVAILABLE DATA.

0 DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT STORAGE PERFORMANCE

SITE: FACILITIES DEVELOPMENT GAS COMPANY SOLAR/1017-79/02  
REPORT PERIOD: FEBRUARY, 1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.320	0.163	-0.303	78	-0.422
2	0.320	0.193	0.040	89	0.789
3	0.111	0.232	-0.131	82	0.910
4	0.411	0.251	0.172	90	1.030
5	0.366	0.267	0.041	100	0.842
6	0.296	0.349	0.007	101	0.899
7	0.347	0.262	-0.018	101	0.900
8	0.369	0.408	-0.048	99	0.975
9	0.376	0.273	0.055	98	0.878
10	0.369	0.304	-0.020	102	1.014
11	0.461	0.444	-0.028	102	0.903
12	0.420	0.345	0.064	101	0.974
13	0.384	0.340	0.036	107	0.991
14	0.364	0.446	-0.088	102	0.984
15	0.356	0.339	0.008	95	0.922
16	0.356	0.397	-0.030	98	1.033
17	0.430	0.428	-0.014	99	0.962
18	0.356	0.428	-0.033	97	*
19	0.281	0.300	-0.015	88	1.016
20	0.218	0.236	-0.020	86	0.993
21	0.213	0.285	-0.026	86	1.000
22	0.368	0.404	0.045	97	1.075
23	0.347	0.291	0.015	96	0.983
24	0.206	0.285	-0.091	92	0.939
25	0.454	0.245	0.078	100	0.932
26	0.157	0.284	-0.107	85	1.121
27	0.446	0.391	0.114	95	1.138
28	0.456	0.370	0.042	99	0.923
SUM	9.784	0.163	-0.161	-	-
AVG	0.349	0.227	-0.006	95	0.920
NBS IN	0200	0201	0202	-	1108

\* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT HOT WATER SUBSYSTEM

SOLAR/1017-79/02

SITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: FEBRUARY, 1979

DAY OF MON.	HOT WATER LOAD MILLION BTU	SOLAR EFF. OF LOAD PER CENT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	SUP. WAT. TEMP DEG F	HOT WAT. TEMP DEG F	HOT WATER USED GAL
1	N	N	0.163	N	1.583	1.583	N	0.163	N	59	NOT	849
2	N	N	0.193	N	1.370	1.370	N	0.193	N	59	NOT	706
3	N	N	0.232	N	1.691	1.691	N	0.232	N	59	NOT	975
4	A	A	0.251	A	1.486	1.486	A	0.251	A	59	NOT	726
5	A	A	0.267	A	1.164	1.164	A	0.257	A	59	NOT	774
6	A	A	0.249	A	1.230	1.230	A	0.349	A	59	NOT	925
7	A	A	0.362	A	1.346	1.346	A	0.362	A	59	NOT	911
8	L	L	0.408	L	1.190	1.190	L	0.408	L	59	NOT	940
9	L	L	0.275	L	1.089	1.089	L	0.275	L	59	NOT	725
10	L	L	0.394	L	1.565	1.565	L	0.394	L	59	NOT	951
11	A	A	0.444	A	0.980	0.980	A	0.444	A	57	NOT	1032
12	A	A	0.345	A	0.926	0.926	A	0.345	A	59	NOT	859
13	A	A	0.345	A	1.243	1.243	A	0.345	A	59	NOT	789
14	A	A	0.446	A	1.459	1.459	A	0.446	A	59	NOT	1057
15	A	A	0.339	A	1.315	1.315	A	0.339	A	59	NOT	1028
16	A	A	0.397	A	0.988	0.988	A	0.397	A	59	NOT	1066
17	A	A	0.428	A	1.124	1.124	A	0.428	A	59	NOT	957
18	A	A	*	A	1.236	1.236	A	*	A	59	NOT	905
19	A	A	0.300	A	1.498	1.498	A	0.300	A	59	NOT	1053
20	A	A	0.236	A	1.157	1.157	A	0.236	A	59	NOT	1195
21	A	A	0.404	A	1.468	1.468	A	0.404	A	59	NOT	861
22	A	A	0.291	A	1.275	1.275	A	0.291	A	59	NOT	781
23	A	A	0.245	A	0.768	0.768	A	0.245	A	59	NOT	935
24	A	A	0.284	A	0.941	0.941	A	0.284	A	59	NOT	1187
25	A	A	0.391	A	1.168	1.168	A	0.391	A	59	NOT	1059
26	A	A	0.379	A	1.577	1.577	A	0.379	A	59	NOT	26142
27	A	A	0.379	A	1.301	1.301	A	0.379	A	59	NOT	974
28	A	A	0.379	A	1.301	1.301	A	0.379	A	59	NOT	9309
SUM	N.A.	-	9.163	N.A.	35.396	35.396	N.A.	0.163	N.A.	-	-	26142
AVG	N.A.	N.A.	0.327	N.A.	1.264	1.264	N.A.	0.327	N.A.	59	N.A.	974
NBS	0302	N700	0300	0303	0301	0305	0706	0311	0313	N305	N707	N309

\* DENOTES UNAVAILABLE DATA.  
0 DENOTES NULL DATA.  
N.A. DENOTES NOT APPLICABLE DATA.



## SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT  
ENVIRONMENTAL SUMMARYSITE: FACILITIES DEVELOPMENT GAS COMPANY  
REPORT PERIOD: FEBRUARY, 1979

SOLAR/1017-79/02

DAY OF MONTH	TOTAL INSOLATION BTU/SQ. FT	DIFFUSE INSOLATION BTU/SQ. FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	1446	NOT	51	57	NOT	NOT	NOT
2	1282		49	56			
3	552		51	57			
4	2131		49	59			
5	2017		50	61			
6	1587		51	61			
7	1834		52	62			
8	1682		53	67			
9	1774		54	59			
10	2024		52	62			
11	2013		54	64			
12	2085		54	65			
13	2126		55	67			
14	1315		56	60			
15	1819		51	59			
16	1777		55	61			
17	2125		53	61			
18	1904		54	61			
19	1257		55	62			
20	1080		55	61			
21	1496		57	59			
22	1728		56	59			
23	1743		55	60			
24	1062		54	62			
25	2164		55	65			
26	991		55	60			
27	2117		54	62			
28	2087		54	63			
SUM	48128	N.A.	-	-	-	-	-
AVG	1719	N.A.	53	61	N.A.	N.A.	N.A.
WPS 10	2001		N113			N115	N114

\* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

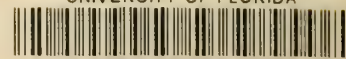
N.A. DENOTES NOT APPLICABLE DATA.







UNIVERSITY OF FLORIDA



3 1262 09052 5774